1   **Inspecting Print Quality Using Digital Watermarks**

2

3   **Filed of the Invention:**

4 The present invention relates to label printing and more particularly to inspecting

5 printed labels.

6

7   **Background of the Invention:**

8 In many manufacturing operations, labels are applied to products or packages at

9 very high speed. It is very important for a variety of reasons that the labels be

10 printed correctly and that they be applied correctly. Among the reasons are the fact

11 that the labels create a product image and the fact that some labels contain notices

12 that are required for legal reasons.

13

14 Automatic label inspection using machine vision is possible. However, labels often

15 use colors and materials which make it difficult if not impossible to effectively

16 inspect labels using relatively simple binary or gray scale inspection technologies.

17 Presently in some situations, colored labels are automatically inspected using a

18 "golden template". With such systems an image of the label acquired by a machine

19 vision system. The acquired image is then automatically compared to the golden

20 template. Various known computerized image correlation techniques can determine

21 if the quality of the acquired image matches established the "golden template".

22

23 In general, prior art automatic label inspection systems are expensive and difficult to

24 maintain. Furthermore existing automatic label inspection systems often involve

25 time consuming set up processes for each new label. Often the set up process

26 requires a high degree of technical expertise.

27

28 The present invention is direct to providing an providing an improved lable

29 inspection system.

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1 **Summary of the Present Invention:**

2 The present invention provides an automatic label inspection system that is

3 relatively inexpensive, flexible and easy to set up. The system and method of the

4 present invention utilizes digital watermarks. With the present invention a digital

5 watermark is embedded in a label. As is conventional in watermark technologyh ,

6 the digital watermark is duplicated many times in the image. That is, the image

7 printed on the label is divided into areas and a copy of the watermark is embedded

8 into each area. Conventional digital watermarks often include both a grid and a

9 payload signal. The present invention merely requires use of the watermark grid

10 signal. A label is inspected by reading the watermark grid signal from each area of

11 the image. The strength of the watermark grid signal in each area is used as a

12 measure of the quality of the printing on the label in that area.

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14 **Brief Description of the Drawings:**

15 Figure 1 illustrates a label divided into areas.

16

17 Figure 2 is a block diagram of a system used to practice the invention.

18

19 Figure 3 and 4 illustrate examples of where the grid signal was detected in the

20 image of two different labels.

21

22 Figure 5 is a block flow diagram of the operation of the invention.

23

24 **Detailed Description:**

25 The present invention utilizes existing digital watermark detection and reading

26 technology such as that described in US patent 5,636,292, US patent 5,710,834,

27 US Patent 5,721,788, US Patent 5,748,783, US Patent 5,768,426, US patent

28 5,841,978 or US patent 6,122,403 all of which are hereby incorporated herein by

29 reference. With the present invention, digital watermarking technology is applied to

30 automatically inspect and determine the quality of printing on a label.

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2 The term label as used herein means any printed image or text that appears on a

3 package or item. The printed image can include text and graphic material or

4 pictures. A label can be a relatively small such as the type of label that provides a

5 notice required by the FDA on a medicine bottles A label may be relatively large

6 such as the label that would appear on the side of a box containing a refrigerator.

7 A label may be glued to an item or it can be text and graphic material printed on a

8 box such as the text and images that appear on many cereal boxes. A label

9 consists of an image printed on a carrier. The carrier can be paper, cardboard or

10 plastic.

11

12 Labels are used to provide information and/or an appealing image to consumers. In

13 may cases labels carry important information. During manufacturing operations,

14 there is a need and desire to quickly and effectively check the quality of the printing

15 on a label and to insure that a label has in fact been correctly placed on an item.

16

17 Known watermark technology such as that described in the above referenced

18 patents, utilizes a watermark that has both a grid and a payload or data signal. The

19 present invention merely requires the use of a digital watermark that includes a grid

20 signal. However, a digital watermark that includes both a grid and a payload signal

21 can also be utilized to carry other useful information as described later with respect

22 to alternate embodiments of the invention.

23

24 Figure 1 illustrates a printed label. A watermark is redundantly embedded into the

25 image. It is noted that the label has some background coloring into which a

26 watermark can be embedded. The label shown in Figure 1 may be a gray scale or

27 a multicolor image. The technology for embedding watermark into such images is

28 well known. The shapes such as 102 merely indicate that the label includes the

29 type of graphic that is conventionally on labels. The lines 105 indicate that the label

30 includes textual material.

1

2 The doted lines in Figure 1 which divide the image into a number of square areas

3 illustrate the fact that the image is divided into areas and the watermark is

4 redundantly embedded into each of the areas in the image. The typical image

5 would be divided in areas, the size of which, would be in the order of one hundred

6 or two hundred pixels square. The lines in Figure 1 merely illustrate that there are

7 multiple areas into which the watermark in embedded.

8

9 Figure 2 illustrates a system for practicing the present invention. A package 201

10 moves along a conveyor 202. The package 201 includes a label 210. A camera

11 211 captures an image of the label 210 and sends the image to a computer 250.

12 The computer 250 includes a conventional operating system (such as for example

13 the Microsoft Widows operating system) and a watermark reading program 251.

14 The output of the watermark reading program 251 goes to a comparison program

15 252 which compares the grid signal in each area to acceptable limits. The camera

16 211 can be a conventional digital camera. It is noted that in alternative

17 embodiments, instead of using a computer with an operating system such as

18 Microsoft Windows, the computer 250 is what is termed an "embedded system"

19 program to perform the required tasks and camera 211 can be an analog camera

20 with a suitable capture card..

21

22 Examples of the result are shown in Figures 3 and 4. In the example given in

23 Figure 3, the grid signal is detected in each tile in which the watermark is

24 embedded. Hence, the detected results indicate that the label was printed correctly.

25 In the example given in Figure 4, in four of the tiles, no grid signal was detected.

26 Hence, the results indicate that this label was not printed correctly.

27

28 In alternative embodiments, algorithms which determine pass/fail criteria based on

29 neighborhood operations are used. For example, a week grid signal in one tile might

30 be acceptable if there were a strong signal in all surrounding (neighboring) tiles. In

1 other alternative embodiments, morphological algorithms are employed to perform

2 erosions, dilations, openings and closings, etc. Furthermore, blob labeling with

3 ensuing feature extraction could be used to find moment data for qualifying defects.

4

5 If a label does not meet the required criteria it is deemed unacceptable. In such a

6 case the package with the unacceptable label is either appropriately marked for re-

7 labeling or the package is removed from the conveyor for further processing which

8 can for example include re-labeling the package.

9

10 The flow diagram in Figure 5 illustrates how the invention operates. The process

11 begins with an image of a label. The image is in digital form. The initial image can

12 either be designed in digital form (as is often done) or a physical label can be

13 scanned to create a digital image. As indicated by block 501, the image of the label

14 is watermarked. This can be done with a conventional watermarking program.

15 During the watermarking operation a grid signal is embedded in each area of the

16 image. That is, the grid signal is redundantly embedded in multiple areas of the

17 image. This grid signal is embedded in the image by modifying the pixels of the

18 image to embed specific spatial frequencies in the image. The changes done to

19 embed these spatial frequencies are such that they can not be recognized by a

20 human observer; however, they can be detected by a watermark reading program.

21 Embedding selected special frequencies in an image can be done with conventional

22 watermarking technology.

23

24 As indicated by block 503, the digital image is printed onto a carrier (i.e. on a

25 physical label) and the physical label is applied to a package. The image can be

26 printed on the carrier (i.e. on the physical label) and the physical label can be

27 applied to the product in the conventional manner.

28

29 Next as indicated by block 505 the labels are passed by a digital cameras and an

30 image of the label is acquired. The watermark is next read from the acquired image

1   as indicated by block 507. Reading the watermark involves determining what

2   spatial frequencies appear in each area of the watermark. This operation is done in

3   a conventional manner. Next as indicated by block 509, a determination is made as

4   to whether the spatial frequencies that represent a grid signal are present in each

5   area of the image. That is a determination is made as to which areas of the

6   acquired image include the grid signal. The result of this operation is data such as

7   that shown in Figures 3 and 4. the image. This can be a simple "yes" no type of

8   operation, or it can take into account the magnitude of the various frequencies. In

9   any event the frequency spectrum of image the signal is examined to determine if

10   there is a watermark grid signal in each area of the image.

11

12   If there is no grid signal in an area where there should be a grid signal, the label is

13   rejected. Alternatively, if the magnitude of the grid signal in a particular are is below

14   a preset threshold the label is rejected.

15

16   Naturally on some labels area of the label are blank, hence, one would not expect to

17   find a signal in these areas and these selected area are ignored. With many

18   existing watermark reading program the first step performed by the program is to

19   determine if the image has been enlarged or rotated. With this application of digital

20   watermark technology, those steps are not necessary, since the size of the acquired

21   image is fixed and the location of the tiles where the watermark is embedded is

22   known. However, if the speed of the convey is such that synchronization is not

23   easily possible, the conventional steps used to locate area where a watermark is

24   located could be used.

25

26   It is noted that the present invention also can be used to detect if a label is in fact

27   present on a package. If for example, a label is misplaced, or if a label is not

28   present on a package, the watermark reading program would not detect a grid

29   signal.

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1   While the embodiments of the invention described above utilize a conventional

2   watermark grid signal, specialized watermark signals could be developed which in

3   some situations would provide a better quality measurement for labels.

4   Furthermore, in alternative embodiments of the invention, in addition to containing a

5   grid signal, the watermark could contain other data. For example, the watermark

6   could include data which allows someone to link to a web site using the technology

7   described in PCT publication WO 00/70585 published 11/23/00 and entitled

8   "Methods and Systems for Controlling Computers or Linking to the Internet

9   Resources from Physical and Electronic Objects". His publication is hereby

10 incorporated herein by reference.   Thus the label inspection process according to

11 the present invention could utilize a digital watermark that is placed on the label for

12 other purposes such as for allowing a consumer to link to a web site.

13

14 While the invention has been described with respect to preferred embodiments of

15 the invention, it should be understood that various changes in form and detail may

16 be made without departing from the spirit and scope of the invention. Applicant's

17 invention is limited only by the appended claims.

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